Systems Engineering Seminar

A Tale of 10 Centers: Observations
in
Systems Engineering Culture
Across NASA

April 13, 2010

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Systems Engineering Leadership Development Program (SELDP) Participants

Agenda

- o SELDP Program

  - o Purpose / Overview

  - o Developmental Assignment

- o Observations

- o SE Topics

  - o Culture

  - o Risk

  - o Knowledge

  - o Competency

  - o Technology

- o Closing Remarks & Questions

- o References

SELDP Program

- o Program Requirements
    - o Prepare NASA Workforce to Take on Next Great Challenge
    - o Ensures Selection of High Potential Candidates at the Right Time in Their Career
    - o Builds on and Integrates Center SE Learning Programs
    - o Provides Hands-On Learning Approach that Incorporates the ***Art and Science*** * of SE
    - o Allows for Individualized Learning Approach to Meet Participant Training & Development Need

- o Program Elements
    - o Developmental Assignments: Hands-On at Centers
        - o Mentoring: Home and Assignment
        - o Job Shadowing: Top SE Leaders
    - o Leadership Development: Models/Experiential Learning
        - o Assessment Instruments: Leadership Self Awareness
        - o Leadership Coaching: Leadership Development
        - o Leadership Training: Leadership Courses/Teambuilding
    - o Benchmarking: With Leading SE Organizations
        - o Center Visits: Greater Understanding Across Agency
        - o Industry Benchmarking: Cutting Edge Organizations
    - o Technical Training: Determined by Gap Analysis
    - o Workshops
    - o Advocate Support

* http://www.nasa.gov/pdf/311198main_Art_and_Sci_of_SE_LONG_1_20_09.pdf

Developmental Assignments

o   Key aspect of SELDP

o   Based on participant application and development assessment

o   Intended to "stretch" or "fill in the gap" for each participant

    o   Will make you "uncomfortable"

    o   Give you experience that you will not get any other way

    o   Work with specific mentor

    o   6 to 12 months at <u>another</u> NASA Center

o   Selected from overall opportunities by advocates

o   Can <u>not</u> be changed

o   <u>Must</u> be "optimized" by participant to maximize experience

    o   If the assignment doesn't seem to be "working," let advocate and mentor know

    o   Just ask and people will be willing to help

Scott's Assignment
Goddard to Kennedy

Assignment: Support the Space Shuttle Program (SSP) as Integration Project Engineer

December 2008 to August 2009

Scott's Assignments

My Assignment

o   Served as an Integration Project Engineer (SE) for SSP processing

o   Supported senior Shuttle Project Engineer

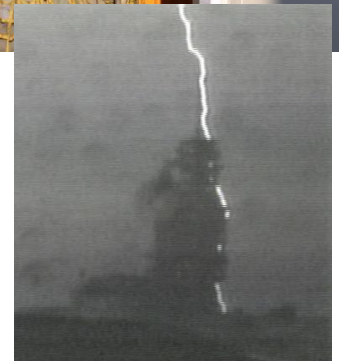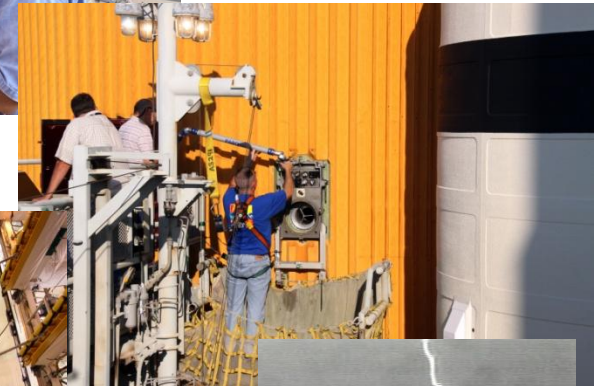o   Short time with ISS Integration & SMA

What I did

o   Learned the details of SSP processing from launch through landing

o   Supported the Project Engineering Integration related duties for SSP spanning the Orbiter, External Tank, and SRB Programs

  o   vehicle problem resolution

  o   Certificate of Flight Readiness

o   PH-I Project Engineers in preparing presentations for Chief Engineer Engineering Review Board, Level III CCBD, Shuttle Daily Program Requirements Control Board and Program Requirements Control Board

o   Resolved outstanding issues for implementing Kennedy Forward Return Link

Scott's Assignments (cont)
STS-127, July 2009

Spray of Debris Falling Aft

Scott's Assignments (cont')

What worked

- o   Gained a greater appreciation of the challenges of getting 30 year-old hardware ready to fly to "spec" every time

- o   Experienced a large, complex, multi-Center program

- o   Observed senior leadership in "action"

- o   Gained a greater perspective of the Agency as a whole

What would I have done differently

- o   Follow a single orbiter through one flow instead of trying to "observe" too many groups

- o   KSC schedules change even more than GSFC schedules
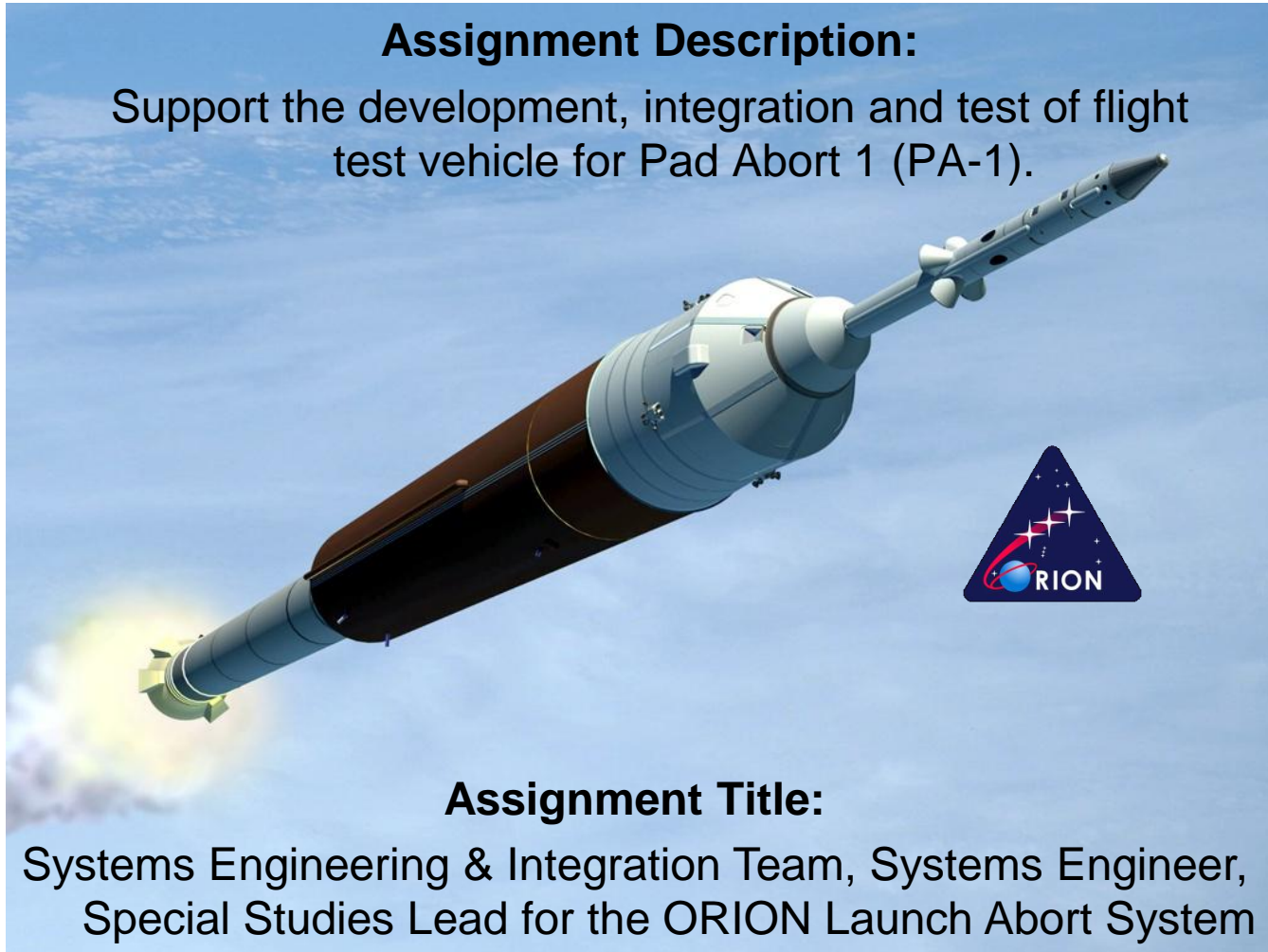
- o   Be open to learning sooner
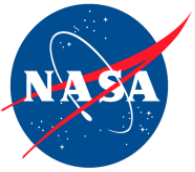
Angie's Assignment
Goddard Space Flight Center – Langley Research Center

Assignment Description:
Support the development, integration and test of flight test vehicle for Pad Abort 1 (PA-1).

Assignment Title:
Systems Engineering & Integration Team, Systems Engineer, Special Studies Lead for the ORION Launch Abort System

Angie's Assignment (cont')
Goddard Space Flight Center – Langley Research Center

SYSTEMS ENGINEERING
Leadership Development Program
Established 2008

(Professional)

Support to ORION LAS, LaRC SED and LaRC Office of Chief Engineer

o   LaRC ORION LAS Systems Engineer, SE&I; including Special Studies.

   o   Exposed to and worked closely with all levels and members of the Team; Program, Project, Systems, Safety, Contracts, Scheduling, Primary Contractor, Subcontractor, etc.

o   LaRC SED

   o   Branch Related and SEDP Program Participation

o   LaRC Office of Chief Engineer

   o   Consult for "How does GSFC do …"

   o   NASA Documentation Reviews

o   LaRC NESC – Independent Review Team Member – MLAS

(Personal)

Participated in some of "the clubs" and took in the "local environment" which furthered the impact of my assignment

o   Langley Karate Club – Cuong Nhu (LaRC => GSFC)

o   Yorktown Battlefield and Waterfront area

o   Local parks and Historic sights

Angie's Assignment (cont')
Goddard Space Flight Center – Langley Research Center

o **LaRC ORION LAS Systems Engineer, SE&I; including Special Studies**

- Led LAS Pyrotechnics Requirements Trace and Supported Orion LAS End to End Requirements Traceability Meeting
- Supported LAS PDR and Verification, Deviation and Waiver Processes
- Created a LAS Roadmap for Path to FTR Review
- Prepared and debriefed LASO on Cable Raceway Hazard Assessment (Requirements, Environments, Structures, Materials, Harnessing - Bird Strike, Fire, Debris, Lightning)
- Supported several LAS Risk Assessments and meetings: FPGA Qualification, Red Plague, LAS Solid Rocket Motor Development and Qualification
- Supported LAS Safety and Hazards Review as a Consensus Team Member. Also supported LASO for CSERP Orion Phase #1
- Served and continue to serve as a mentor for new SELDP class

o **LaRC SED**

- Prepared and debriefed monthly reports to SE&IO Branch Management and Technical/Program Mentors
- Participated in Field Visit to Johns Hopkins University, Applied Physics Laboratory
- Helped plan and Participated in Field Visit to Goddard Space Flight Center

o **LaRC Office of Chief Engineer**

- Support to OCE for 7123.1A, 7150.2 and MOE/MOP discussions

o **LaRC NESC – Independent Review Team Member – MLAS**

- Opportunity to review the Passive Control Abort System

Angie's Assignment (cont')
Goddard Space Flight Center – Langley Research Center

What Worked:

o Broad exposure to the Project and Program with accessibility to all team members.

o "Active" learning-based technical assignment with task and work product responsibilities

o Combination of required training elements for both the SELDP Program and LaRC SEDP

  o Systems Thinking, Requirements Development, Crucial Conversations, APM/ASE, and workshops; PM Challenge, Science Mission and Systems Design and Operations (SMSDO), Overview of Program Management and Systems Engineering (taught by John Newcomb) as part of SEDP, and Root Cause Analysis Seminar

o Multiple mentors (program assigned and discipline experts)

o Transferrable experience between GSFC and LaRC (both technical and leadership based)

Angie's Assignment (cont')
Goddard Space Flight Center – Langley Research Center

What I learned or have a greater appreciation for:

o   Greater appreciation of clear communication and dynamic teaming arrangements on a highly distributed team.

o   Address questions related to project governance documentation, including SE documentation (NPD 1000.0A, NPR 7120.5, NPR 7123.1A)

o   Spacecraft land – hand off to the vehicle for the mission, LAS land – the vehicle is the mission

o   Advocate for requirements analysis, safety, risk and operations considerations as part of early formulation activities

o   Understand and actively support the balance between Program Management and System Engineering (Both APPEL APM/ASE and OPMSE)

o   Better appreciate the Performance, Schedule and Cost triangle

o   Actively "translate" - Teammates, Projects, Centers, Stakeholders, Industry (INCOSE)

o   A growing network with SELDP, SEDP and other LaRC employees and groups

Observations Overview

The topics for discussion are our class perceptions…

o Developed and shifted throughout the year based on:
  - o Experience at our new centers
  - o Opportunity to reflect on our home centers
  - o Understanding the external forces driving the Agency
  - o Dialogues with Senior Management, EMB, Administration, Classmates, etc.

o Insights from Top Industry Systems Engineers
  - o Our "list" of Challenges and Opportunities is not only applicable to NASA
  - o US based and Internationally based SEs shared insights which show these are "global" and "common" for projects with one or more external interfaces.

o Challenges and Opportunities
  - o Understanding your Sandbox and the one you want to or need to play in
  - o Investing in our Agency's future
    - o Workforce (building our people)
    - o Competencies (maintaining our excellence)
    - o Technology (exploring our creativity for problem solving through innovation)
    - o Training (enhancing our skill set)
  - o Mentoring is essential (sharing the knowledge, transferring the experience torch)
  - o Coaching as a feedback mechanism - (growing effective leaders)

o Openness and Accessibility to Management
  - o Direct feedback session with GSFC 500 Management and Division Heads

SE Topics – NASA Culture

o **Communication -** Hierarchical process:
  - o JSC, MSFC, JPL, KSC, GRC – larger centers, more hierarchical communications lines.
  - o Remaining centers are somewhat smaller and do not have this type of communication system. Community, flexible, family, 'hands off', supportive are terms that were used to describe communication in some of these centers
  - o Note: GSFC falls "in the middle" - larger center, smaller program based groupings; with somewhat Division/Project driven communication practices

o **SE Function –** SE function (as defined in NASA SE handbook) implementation process differs amongst centers. Each center defines this function differently and treats and has different expectations of 'SE's.'
  - o JSC – PM's have more influence than SE
  - o JSC – SE&I is a process and separate organization
  - o SSC – SE disconnected from PM, SE lacks 'art'
  - o DFRC – SE&I is job of all engineers
  - o JPL, LaRC – SE covers all project/program life cycles
  - o GSFC – SE covers all phases, but is typically broken up by organization
  - o KSC – SE's are actually sub-system engineers

NOTE: SE function is implemented under different names and divisions due to size of center/project

SE Topics – NASA Culture

o **SE Training**

  o GRC, GSFC, JPL have strong, mature SE training programs. These centers expend a lot of resources on formal SE training. SC, MSFC, JPL, KSC, GRC – larger centers, more hierarchical communications lines.

  o KSC, JSC, LaRC – recently initiated SE training programs.

  o Remaining centers spend little to no resources on formal SE training.

o **Workforce Responsibilities (Teaming)**

  o CS and Contract Support Personnel

  o Engineer and Technician

  o Others???

  o "It's not my job" and "That's not your job"

NASA Cultures

Observations on KSC

- Every day is launch day
    - Start early, work late, work whenever
    - Difficult to balance work and family
    - People extremely dedicated to the work and "doing the right thing"
- SSP "live and breath" requirements and documentation
- Clear and significant demarcation between CS and contractors
- Good at solving problems others have created in the design
- Things KSC does well (at least on SSP)
    - Reviewing what worked and what didn't after every major operation
    - Celebrating and praising achievements and thanking people
    - Finding alternatives to the problem to stay on schedule

NASA Cultures (cont')
Observation on LaRC

o   A healthy mix of History, Cutting edge technology investment and Agency support service offices

   o   The other "A" – NASA/Langley is the Home of the United States first civilian aeronautics research laboratory (established by National Advisory Committee for Aeronautics in 1917)

   o   Home to our NESC, IPAO, and ESSP

   o   Small but Mighty: supported everything from training of the first Mercury Astronauts, to developing the entry, decent and landing flight dynamics simulation system for the Mars Exploration Rover Mission.

   o   Technology development efforts to improve air transportation; both in materials studies and creation, as well as through air traffic control simulation center.

   o   Leading the effort in ensuring our Astronauts are safe through design, development, build, integration and test of the ORION Launch Abort System. (And ARES Program).

   o   And…Yes, LaRC does spacecrafts also!

o   Workforce

   o   Very experienced with an average of almost 21 years federal service

   o   More than half the workforce is in Engineering, Research and Scientific Fields
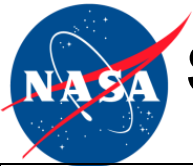
NASA Cultures (cont')

A New Perspective of GSFC

- We do a broad range of work for every aspect of science missions
    - From research to design to I&T to launch to operations to decommissioning
    - Not every Center has this broad work
- Tend to look inside the "village" first
    - Ability to be self-sustaining/sufficient
    - Less accepting of outside ideas (i.e. not invented here)
- We tend to "tolerate" bad behavior
    - Open & dynamic discussion
    - "share any thought at any time"
    - Dissenting opinions encouraged at all levels

SE Topics – Risk

o Risk is used differently at Centers and even at Projects

   o 5 x 5 matrix used in required risk meetings

   o More often than not, risk system used to document problems

   o Monthly meetings were about the only time risk was discussed

o SELDP Risk experience at JPL

   o Risk was part of every conversation at every level – not just project management

   o Identification and acceptance of residual risk when solving problems

   o 5 x 5 matrix used when needed as a communication tool

o Risk experience post-SELDP – Orion Project

   o Formal risk system used for multiple purposes

      o Tracks risks with mitigation plans and problems with recovery plans

         o Visibility of risk reviews helps to get mitigations/recovery worked

      o Documentation of cost threats to allow a probabilistic assessment of final cost

   o Probabilistic Risk assessment used for all design decisions and to determine where resources should be applied

o **Tools (SE Tool Box)**
- o APPEL/Training
- o Mentoring
- o Coaching
- o Seminars
- o Network; "Affiliations"
- o Books
- o Evaluations (MBTI)
- o Translators

o **Techniques**
- o What does your Project Communication Plan say and expect?
  - o Oral, visual, email practices, secure conferencing
- o Understand the TEAM and refine the methods for communication:
  - o Size, location, affiliation, systems access requirement, can influence how to conduct business
- o Get out your walking shoes or hop on a plane – Walk the halls/Face time!

o **Time**
- o "Take a TIMEOUT"
  - o Pause and Learn Sessions
  - o Document the "final" product as well as if not better than the active project phases.
- o Experience level or "time on the job" is not a factor in ability to contribute to a team.

o **Trust**
- o Are you approachable?
- o Do you respect/support, give air to and encourage dissenting opinions?
- o Do you share information in times of uncertainty?
- o Do you give clear direction and use powerful requests?

SE Topics – Competency

o Discipline expertise is needed in order to be good SE; need strong technical base
  o Development of a single technical base that has been developed and applied to sub-system design provides the foundation of engineering techniques/communication needed to engineer the larger system.

o Hands-on training (subsidized by classroom training), real-life experience, getting your hands dirty, application of knowledge

o Smaller-based, short-term projects where **mission success** is not absolutely critical make for best training ground (i.e.. technology development projects, robotic missions where a space crew is not at risk)
  o "failure is an option"
  o Provides training on risk vs. innovation (meeting min requirements)
  o Provides hands-on training for balance of cost, performance, and risk
  o Provides project life-cycle exposure
  o MLAS: resident engineer versus junior engineers

o Agency challenge to develop good SE for large, complex programs

SE Topics – Technology

o Technology development often driven by
- o Mission enabling needs
- o Someone's cool idea

o Research "happens" at three plateaus
- o TRL 1-3: stuff that's cool or 40 years out there
- o TRL 4-6: land of the lost
- o TRL 7-9: operations focused

o Difficult to get flight projects to incorporate new technology
- o Added risk to project
- o May not be necessary to satisfy requirements
- o Added burden

o Smaller projects with "higher" risk may be opportunities for technology (ST series)

o Technology attracts new talent and innovation

Closing & Questions

o SELDP - definitely a worthwhile experience and investment of time
  - o Professional growth through being "out of comfort zone" adds to the SE Tool Box
  - o Finding your values & vision, expressing them as "results" by taking some "action" - is essential to sharing your personal professional core beliefs

o Cultural Observations help to:
  - o Test existing perceptions and stereotypes for each center and Agency as a whole
  - o Obtain a better understanding of each Center's unique role in Agency success
  - o Understand how to best influence collaboration IF a center is willing to look beyond established boundaries for solutions

o Questions for you to ponder:
  - o Are SEs born or made?
  - o Why would someone want to be led by you?
  - o Will you do the "right" thing when no one is looking or it's unpopular?
  - o Do you shoot the messenger or actively listen when receiving "bad or difficult" news?
  - o Do you treat others as you think they want to be treated, or as you want to be treated?
  - o What do you do to engage, support, motive, inspire your team mates and co-workers?
  - o The next time you get asked "Where to you work?" will you stop after answering "NASA"?

Questions for us???

Back Up Slides
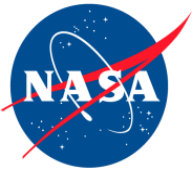
Participant Selection

- o Call Letter Released
- o Application Form
- o Center Nomination Review
    - o Internal review
    - o Center Endorsement
    - o Center Ranking
- o Engineering Management Board (EMB) Member Review & Rating
    - o Each Center reviews and rates nominations
    - o Center ratings are collected and averaged
- o Invitation for Interview by EMB panel
- o Advocate assignment discussion
- o Participant notification / selection
- o Begin program

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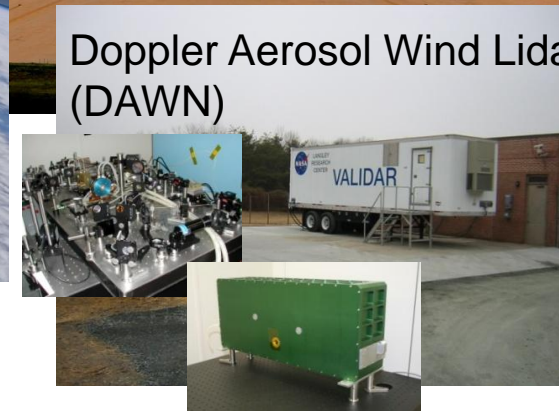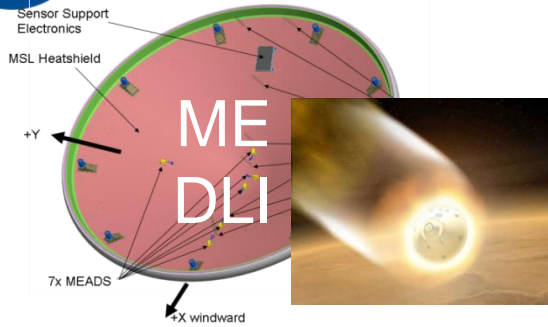
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Langley Systems Engineering Development Program (SEDP) Objectives: Provide…

- **Experience**
  - **Assign trainees to projects/tasks that require application of skills and opportunity to expand SE knowledge base**
- **Mentoring**
  - **Assign a Senior System or Chief Engineer from a different project/task**
- **Training: On-the-job**
  - **By experienced System and Chief Engineers on the same project/task**
    - » **Day-to-day interaction to achieve shared project goals, objectives, and tasks**
  - **Conduct Systems Engineering Field Trips**
    - » **Utilize recognized expertise in NASA and Industry**
- **Training: Classroom**
  - **NASA Academy of Program/Project & Engineering Leadership (APPEL) Baseline**
    - » **Mandatory APPEL Level 1 (Awareness) and Level 2 (Application) courses**
      - • **Priority over all other assignments**
    - » **Additional APPEL courses as schedule permits**
  - **Industry, Academia, Other Government Agencies**
    - » **On-site vendor supplied SE courses**
    - » **Local (or virtual) university SE courses**

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References

- SEED
  - The goal of the SEE D Program is to make available to our engineers a curriculum and experiences to foster systems engineering fundamentals from new hires through continued training for our senior Systems Engineers.
  - Ed Amatucci, 6-0027, edward.g.amatucci@nasa.gov
  - http://seed.gsfc.nasa.gov/
- SECP
  - Science & Engineering Collaboration Program is conducted in conjunction with SEED
  - Ed Amatucci, 6-0027, edward.g.amatucci@nasa.gov
  - http://seed.gsfc.nasa.gov/
- SELDP
  - The Systems Engineering Leadership Development Program provides leadership development and technical training in systems engineering.
  - Christine Williams, christine.r.williams@nasa.gov
  - http://www.nasa.gov/offices/oce/appel/seldp/index.html
- APPEL
  - APPEL provides leadership, advice, direction, and support to meet the learning and development objectives of the NASA program/ project management and engineering community.
  - http://www.nasa.gov/offices/oce/appel/home/index.html
- Lessons Learned & Knowledge Sharing
  - *NASA lessons learned is a great way to leverage your knowledge sharing and expertise.*
  - http://nen.nasa.gov/portal/site/llis/LL